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Southern Alberta Landscapes

MEETING THE CHALLENGES AHEAD ▶▶

Review of the Regional Input-Output (IO) Model Developed for SAL

Prepared for
Alberta Environment
By Atif Kubursi, David Butterfield and Steven Spencer
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Alberta Environment has retained Econometric Research Limited (ERL) to review and evaluate the SAL IO Model developed by Suren Kulshreshtha and Dale Russell (K&R). The model integrates social, economic, and environmental information for southern Alberta and assesses the consequences of potential development scenarios on the region over the next two generations.

The Terms of Reference for the review as set by Alberta Environment are extensive and cover issues of appropriateness of methodology, accuracy of data collected and adjusted, suitability of calibration and precision of the estimates.

We begin our review by first restating the objectives of SAL before examining the extent to which SAL IO methodology, data, calibration and estimated parameters are relevant and appropriate to deal with the questions and issues of sustainability in the Southern Alberta region over two generations.

More specifically the Terms of Reference defined by Alberta Environment for this review set the following specific tasks:

- Examine the structure, assumptions, calibration and estimation of the SAL IO Model underpinning the analysis as it relates to comparative economic analysis at a sub-provincial scale.
- Assess whether it allows for useful and reasonable simulations of economic activity over long time-periods in support of current land and resource management decisions.
- Evaluate alternative modeling procedures such as Computable General Equilibrium systems and identify key strengths and weaknesses of these alternative systems.
- Review the *ALCES*-IO interface module and comment on the linkage between the two models for regional economic analysis.
- Evaluate the process by which the provincial IO model was recalibrated for the SAL region, with special attention to the following:
    - Estimation of regional sector outputs and coefficients.
    - Disaggregating of agricultural production, manufacturing, and mining sectors.
    - Evaluate key areas of the SAL IO model including, but not necessarily limited to:
        - Estimation of propensity to spend.
        - Employment module.
        - Modeling Type I vs. Type II impacts.
    - Development of the Impact Analyzer program.
- Make recommendations for addressing deficiencies.

SAL has two phases. The purpose of SAL Phase 1 was to identify the key issues that need to be addressed in order to ensure a sustainable future with outcomes that are acceptable to citizens of the region and of the province, while Phase 2 addressed the issue of estimating the future socioeconomic impacts on the region of the different scenarios. The results of Phases 1 and 2 aim at providing a guide for sustainable development in the southern Alberta region.

Methodological Issues

The evaluation is organized according to the issues and questions raised in the terms of reference. We address each question separately and in the order it was raised. We begin with theoretical and methodological issues and proceed to questions about data reliability and calibration relevance and accuracy. We also deal with issues of empirical compromise and end up with a set of recommendations.

Structure and Assumptions

The core structure of the SAL model is an IO system. This system captures indirect effects (Open Version) and induced effects (Closed Version) of changes in the final demand (autonomous consumption, investment, government purchase and exports) of the economy. The Canadian inter-provincial model that the authors have adopted for their analysis and simulations is a rectangular system where an industry produces more than one commodity and where technical coefficients are segregated (separated) from market shares. This is a great advantage over the original Leontief square matrices. The mathematical structure of this system is simple and straightforward. But its simplicity could be deceiving as there are many complications and subtleties that require careful specification and development.

Input Output Mathematics

Input Output analysis is a useful mathematical tool capable of quantifying the patterns and magnitudes of interdependence among sectors and activities that are often not revealed by aggregate economic analysis. It has three basic advantages which include:

First, regardless of the inherent value of primary activities, to the extent that these activities involve the use of scarce resources they generate secondary economic consequences that can be measured and compared.

Second, economic impacts are only partially captured by assessing direct expenditures. In as much as the economy is a complex whole of interdependent and interacting activities, there are some significant indirect and induced impacts associated with direct expenditures. These indirect and induced impacts are often larger than the direct impacts.

Third, spatial economic impacts follow from the location patterns of economic activities. The IO framework is a convenient and flexible framework for capturing these spatial impacts.

Obviously, the motivation for the IO model in SAL is the desire to specify a system that can be disaggregated to the level of industrial detail that is consistent with the ALCES model. The IO models are particularly useful in this respect, if not unique. These models are built on a simple specification of the relationship between inputs and outputs. The assumption that such relationships are linear is both an important simplification and a restriction. The advantage of the simplification is that the calculations required to solve the model are made more tractable. The disadvantage is of course that the assumption may be wrong, and that this error may matter particularly over the long horizon envisaged in the applications of SALIO model.

The IO model focuses on two aspects of the interrelationships among the level of output of different industries-- the input requirements of production, and the composition of demand for outputs. That these aspects can be easily modeled mathematically is problematic. There are many complexities that need to be identified and preserved to capture the expected impacts accurately and consistently.

The structure of K&R model are not fully specified but the discussion about netting imports and the way the system is closed leaves the impression that there are a few issues with the way K&R specify the open model or the way they close it. That is why we opted to completely specify the system that we work with in Alberta and invite K&R to reconsider using it.

The Market Share Matrix:

Assuming that the share of commodity i produced by industry j is fixed, we may write:

(1) $V_{ji} = d_{ji}q_i$

where $dji = \frac{V_{ji}}{q_i}$ represents the proportion of commodity i produced

by industry j. This assumption, together with the industry-output identity, implies that industry gross outputs can be calculated from commodity outputs.

(2) $g_j = \sum_i V_{ji} = \sum_i d_{ji}q_i$ j=1,2,...,m

This commodity-industry composition may also be represented by a market share matrix, $D = ||d_{ji}||$, so that the vector of industry gross outputs, {g}, is related to the vector of commodity gross outputs, {q}, by the following matrix equation:

(3) $\{g\} = [D]\{q\}$,

where { } indicates a column vector and [ ] indicates a matrix.

Thus, the fixed market share assumption implies that the production of the jth (multi-product) industry is a weighted sum of the commodity outputs which it produces, where the weights are the coefficients d_{ji}. These weights sum to one across industries. Since

$q_i = \sum_j V_{ji} = \sum_j d_{ji}q_i$, implies

$$(4)\ \sum_{j} d_{ji} = 1 \qquad \text{for } i=1,2,\ldots,n.$$

The Industry-Technology Matrix:

The production function underlying the production process is assumed to be of the fixed proportion type (generally known as a Leontief production function).

$$(5)\ g_j = \underset{i}{\mathrm{MIN}} \left[\frac{U_{ij}}{b_{ij}}\right] \qquad \text{for } i=1,2,\ldots,n \quad j=1,2,\ldots,m$$

where $b_{ij} = \frac{U_{ij}}{g_j}$ is the amount of commodity i needed to produce one unit of output j.

Thus the use of each commodity is assumed to be a fixed proportion of industry gross output:

$$(6)\ U_{ij} = b_{ij} g_j$$

This assumption allows the total intermediate use of each commodity to be calculated from the industry gross outputs:

$$(7)\ \sum_{j} U_{ij} = \sum_{j} b_{ij} q_j$$

If we arrange the input-proportion coefficients in a matrix, $B = \|b_{ij}\|$, the vector of total intermediate uses of each commodity can be calculated from the vector of industry gross outputs.

$$(8)\ [U]\{1\} = [B]\{g\}$$

If we let $F_i = \sum_{s} F_{is}$ represent the total final demand use of each commodity and arrange these in a "final demand" vector, f, the commodity-balance identities can be represented in matrix form.

$$(9)\ \{q\} = [B]\{g\} + \{f\}$$

The matrix equation forms of the commodity-industry model (3) and the commodity-balance model (9) form the core of the input-output model. These allow the commodity outputs and industry gross outputs to be calculated from a given vector of final demand commodity uses. Substituting (3) into (9), we have:

$$(10)\ \{q\} = [B][D]\{q\} + \{f\}.$$

This matrix equation can then be solved for the commodity output vector:

(11) $\{q\} = [I - BD]^{-1}\{f\}$.

The analogy between (11) and the familiar Leontief system $\{q\} = [A]\{q\} + \{f\}$ is immediately apparent. The matrix [A] would be equivalent to the matrix [B] if the [D] matrix was an identity matrix, implying that every industry produced only one commodity. In this respect the "square" Leontief framework is inadequate as changes in the matrix [A] may correspond either to a technological change in input proportions or to a shift in market shares. The "rectangular" framework separates these effects.

By pre-multiplying (11) by the market share matrix, [D], we can solve for industry outputs.

(12) $\{g\} = [D]\{q\} = [D][I - BD]^{-1}\{f\}$

An equivalent mathematical expression to (12) may be obtained directly by first pre-multiplying the commodity-balance model (9) by the market share matrix [D]:

(13) $\{g\} = [D]\{q\} = [D][B]\{g\} + [D]\{F\}$

and subsequently solving (12) for the industry gross output vector.

(14) $\{g\} = [I - DB]^{-}1[D]\{f\}$

The Output-Income Relationship:

In order to calculate the income associated with a given forestry activity vector, further assumptions must be made concerning the primary input matrices. Five basic components define the elements of the matrices Y and Y^F. First, we have labour income, which includes the wage payments and benefits in each industry j, W_j, and in each category of final demand s, W_s. Labour income is assumed to be a constant proportion of industry gross output.

(15) $W_j = w_j g_j$

Second, we have net unincorporated business income in each industry j, E_j, and each final demand category s, E_s. Net unincorporated business income in each industry is also assumed to be a constant proportion of industry gross output.

(16) $E_j = e_j g_j$

Third, we have other operating surplus for each industry j, OOS_j, and each final demand category s, OOS_s. Again, this element is assumed to be a constant proportion of gross output in each industry.

(17) $OOS_j = oos_j g_j$

Fourth, we have indirect taxes less subsidies in each industry j, T_j, and final demand categories, T_s. This element is also assumed to be a constant proportion of gross output in each industry.

(18) $T_j = t_j g_j$

Fifth, we have non-competitive imports in each industry, MNC_j, and final demand category, MNC_s. As above, this element is assumed to be a constant proportion of gross output in each industry.

(19) $MNC_j = mnc_j g_j$

These assumptions allow the calculation of primary inputs associated with a given final demand vector. Once the vector of industry outputs, g, has been calculated it can be used to calculate the corresponding primary inputs. Thus labour income in industry, W, can be calculated from

(20) $W = \langle w \rangle \{g\} = \sum_j w_j g_j$,

where <w> denotes a row vector of labour income coefficients, w_j. The total wage bill in the economy, W_T, is then given by

(21) $W_T = W + W_F$,

where $W_F = \sum_s W_s$ is the total wage income associated with final demand. In a similar manner we can calculate total net unincorporated business income, UIC, and total other operating surplus, OOS:

(22) $UIC = \langle e \rangle \{g\} + UIC_F = \sum_j e_j g_j + UIC_F$,

where $UIC_F = \sum_s UIC_s$ is the total net unincorporated business income associated with final demand.

(23) $OOS = \langle oos \rangle \{g\} + OOS_F = \sum_j oos_j g_j + OOS_F$,

where $OOS_F = \sum_s OOS_s$ is the total other operating surplus associated with final demand.

The calculation of total taxes, T, is more complicated since it equals the sum of indirect taxes less subsidies on industry output and final demand, import duties on competitive imports, and direct taxes on wages, unincorporated business income and profits.

(24) $T = \langle t \rangle \{g\} + T_F + \langle tm \rangle \{mc\} + tax_1(W^T + UIC_T) + \langle dt \rangle \{g\}$,

where $\langle t \rangle$ is a row vector of indirect tax coefficients, t_j;

$T_F = \sum_S T_s$ is the total indirect tax less subsidies associated with demand;

$\langle tm \rangle$ is a row vector of import tax coefficients (tariffs), tm_i;
$\{mc\}$ is a column vector of competitive domestic imports of each commodity, MC_i;
tax_1 is the average income tax rate; and
$\langle dt \rangle$ is a row vector of average corporate profit tax rate for each industry, dt_j.

There are two types of imports in the model, competitive and non-competitive. Competitive imports, which make up the major portion, are imports for which there exist domestically produced counterparts. Non-competitive imports have no corresponding domestic production. They include items such as coffee beans and tropical fruits. Competitive imports are assumed to be a constant fraction of total industry and final demand use (exclusive of imports) for each commodity.

(25) $MC_i = m_i \, [\sum_j b_{ij} g_j + F_{oi}]$

where m_i is the fraction of total domestic use of commodity i supplied by imports and F_{oi} is the final demand use of commodity i exclusive of imports. In matrix form (25) becomes

(26) $\{mc\} = [m]\,[[B]\{g\} + \{f_o\}]$,

where [m] is a diagonal matrix of m_i values. Non-competitive imports by industries are related to industry outputs and are added to non-competitive imports in final demand to calculate total non-competitive imports, MNC.

(27) $MNC = \langle mnc \rangle \{g\} + MNC_F$,

where $mnc = \langle mnc_j \rangle$ represents the fractions of non-competitive imports per unit of gross output in each industry j and $MNC_F = \sum_S MNC_s$.

Total imports are the sum of competitive and non-competitive imports.

(28) $M = \langle 1 \rangle \{mc\} + MNC$

Domestic Output and Imports

The assumption that competitive imports are proportional to domestic commodity use as in (25) and (26) requires modification of the commodity balance model (9). Equation (9) states that

$$\{q\} = [B]\{g\} + \{f\},$$

where the final demand vector, f, includes negative entries for competitive imports. If we redefine final demand to exclude competitive imports and denote this new value F_{oij}, then

$$(29)\ \{f\} = \{f_o\} - \{mc\}$$

and the commodity balance model can be rewritten as

$$(30)\ \{q\} = [B]\{g\} + \{f_o\} - \{mc\}.$$

Substituting the competitive import equation (26) eliminates competitive imports from the commodity balance model.

$$(31)\ \{q\} = [B]\{g\} + \{f_o\} - [m\hat{}][[B]\{g\} + \{f_o\}]$$

or

$$\{q\} = [I - m\hat{}][[B]\{g\} + \{f_o\}]$$

Now use of the commodity-industry model allows calculation of commodity outputs and industry gross outputs from final demand excluding competitive imports. Using the commodity-industry model

$$(32)\ \{q\} = [I - m\hat{}][[B][D]\{q\} + \{f_o\}],$$

which implies

$$(33)\ \{q\} = [I - [I - m\hat{}]BD]^{-1}[I - m\hat{}]\{f_o\}$$

and

$$(34)\ \{g\} = D\ [I - [I - m\hat{}]\ BD]^{-1}[I - m\hat{}]\ \{f_o\}.$$

Alternatively, the vector of industry gross outputs can be calculated by pre-multiplying the commodity-balance model by the make matrix.

$$(35)\ \{g\} = [D]\{q\} = [D][I - m\hat{}][[B]\{g\} + \{f_o\}]$$

which implies

$$(36)\ \{g\} = [I - [D](I - m\hat{})[B]]^{-1}[D][I - m\hat{}]\{f_o\}$$

Closing the Model

The equation systems in (33) and (34) solve only for initial and indirect domestic commodity and industry output. Final demand components are treated as exogenous to the system. This treatment is not adequate because consumption can be expected to be linked to the level of labour income. Thus a final demand vector which implies a larger labour income should also imply more consumption. When the consumption is related to income, the solution of the system includes not only direct and indirect effects, but also income "induced" effects. Thus adding a relationship linking consumption, C, to "income", N completes the model:

(37) $C = bN$,

where b is the average propensity to consume out of income.

"Income" is defined as the sum of labour income, W, and net income of unincorporated business, UIC. Thus, income is related to gross industry outputs by the vectors of primary input coefficients w and e.

$$(38)\ N = \sum_j (w_j + e_j)g_j + (w_c + e_c)C + W_F$$

$$= [\langle w\rangle + \langle e\rangle]\{g\} + (w_c + e_c)C + W_F,$$

where W_F is the sum of labour income associated with all final demand components except consumption and competitive imports.

The integration of consumption into the model is completed by assuming that the values of commodities and primary inputs that enter into consumption expenditure are fixed proportions of the total value of consumption:

(39) $C_i = c_iC \qquad i=1,2,\ldots,n$

or, in matrix form,

$\{f_c\} = \{c\}C$,

where c_i is the proportion of consumption used to purchase commodity i and {c} is the column vector of c_i's, and by assuming

(40) $W_c = (w_c + e_c)C$,

where w_c is the proportion of the total value of consumption spent on labour and e_c is the proportion of the total value of consumption which generates net income of unincorporated business.

The "income" concept defined in (38) does not include dividends, government and private transfers or income taxes and other direct taxes and may, therefore, not accurately represent personal income. On the other hand, the inclusion of dividends, government transfers and direct taxes would require information on the distribution of dividends and other private transfers between Ontario, the other provinces and abroad. This information is not available.

The inclusion of consumption within the system modifies its structure, which now assumes the following configuration:

$$(41)\begin{bmatrix} \dfrac{I-[D][I-m^{\wedge}][B]}{-(\langle w\rangle+\langle c\rangle)} & \dfrac{-[D][I-m^{\wedge}]\{c\}b}{1-(w_c+e_c)b} \end{bmatrix}\begin{bmatrix} \dfrac{g}{N} \end{bmatrix}=\begin{bmatrix} \dfrac{[D][I-m^{\wedge}]\{f\}}{W_F} \end{bmatrix}$$

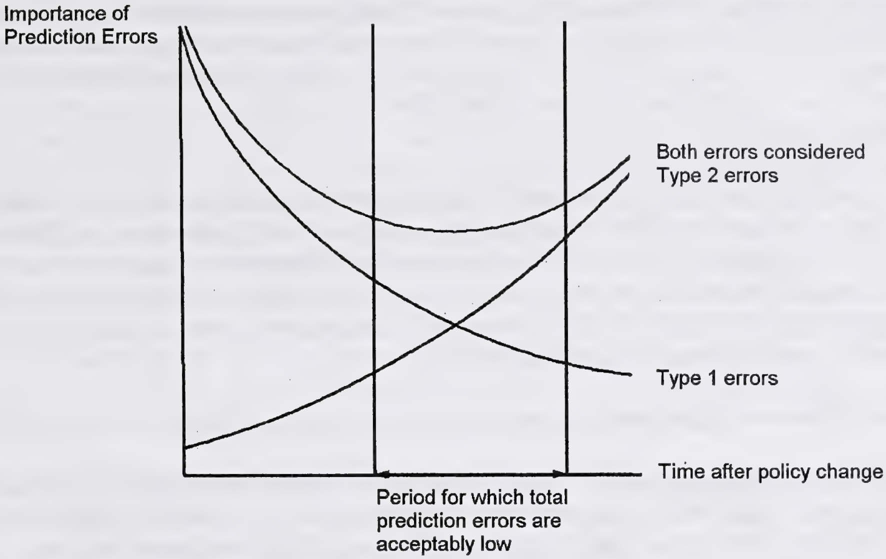
It is this complete model captured in equation (41) that should guide the calculation of the multipliers in order to insure that a proper accounting of the many complexities of the relationships among the many variables of the model are used appropriately and in a consistent manner.

Time Horizon

A key aspect of all input output models that is critical to the SALIO applications here is the implicit specification of the time horizon for which the model forecasts are relevant. The typical open IO model assumes that output changes are equal to changes in the demand in industry output and that purchases of inputs are equal to their use. It thus assumes that sufficient time must elapse for producers' expectations to have adapted to changes in demand, so that there are no changes in inventories which may have to be reversed in subsequent periods. The model is **thus not a short-term model** oriented to tracking quarterly fluctuations in industrial output.

On the other hand, the model assumes that the way in which materials and factor inputs may be considered is unchangeable-or at least will not change in a significant manner from the way in which inputs are currently considered by producers. Thus assuming a fixed (unchanged) technology and a limited opportunity to adapt producers' capital to allow different ways of consuming inputs; the predictions of the input-output model are likely to become increasingly incorrect as time passes after the introduction of a scenario change. As a result, while not a model of output determination in the short run, the **model is not a long run model** either. Its application to trace impacts over two generations is not advisable and could lead to significant errors. The display in Figure 1 shows clearly the period range where the model is most applicable and where errors are minimized.

Figure 1 – Prediction Errors for Simple Input/Output Models



In effect, the model as is currently adopted in the SALIO construction is subject to two types of error. First, there are errors that would arise from the omission of inventory fluctuations and other causes of short-run variations in relationships among material flows. Second, there are errors that would arise from specifying a fixed production technology and fixed composition of demand. Errors of the first type are not serious in the type of applications the SALIO model would be used because as the length of horizon is lengthened these errors decrease in importance (see Figure 1). The second type of errors increase as the length of the horizon is lengthened. There is a middle range (a period of 2-5 years) during which the IO predictions are most likely to be accurate. Even in the middle range, they are of course still subject to the two sources of error but their sum is minimized.

Regionalization of the IO

A third source of error emerges when regional IO coefficients are assumed to be identical regardless of region as if industries are homogeneous and production were not subject to the presence of economies of scale or the laws of comparative advantage. If industries are not homogeneous and different firms locate in different regions of the Province to reflect and capitalize on regional resource endowments and to minimize transport costs and reap economies of scale, then products produced by firms in an industry in one region are not in general the same as the products produced by firms in the same industry in another region. The SAL study suggests that the LQ (location Quotient) is the determinant of whether the technical coefficients of the IO matrix are identical is a major oversimplification that can result in major errors. The regional differentiation in technical coefficients in SALIO is solely based on whether the LQ is greater or equal to one. If LQ is less than one, then the coefficient is reduced by the value of the LQ. This is a typical error in regionalization of IO systems that is at the heart of the difficulties inherent in these models and is perhaps also a failing of the SAL regionalization procedure. Equally important are the additional difficulties that would arise from use of LQ in specifying regional technical coefficients. This relates to the assumption that industries would supply a proportion of regional demand that is proportional to their share of total employment in the region. This may not be true if other considerations influence the pattern of interactions among industries such as ownership structures, transport costs, differentiation of products, etc. It surely does not make sense to suggest that an industry would supply 70% (i.e., its LQ=70%) of the demand of another industry regardless of its proximity to the supplying industry even when it does not have the capacity to supply all of the regional demand.

To the extent that there is more opportunity for substitutability among commodities of the same industry produced in different regions than among commodities produced by different industries, more regional differentiation in the regional coefficients is necessary. As a result of this fact, the multi-regional input-output model is more sensitive to specification errors arising from the assumption of fixed proportions applied to inter-regional commodity flows. We have not seen any consideration of this issue in the SAL system.

Feedback Effects on Aggregate Demand

The effects on aggregate demand of changes in earnings (income) resulting from changes in production can be modeled by endogenizing the household sector reflecting the different assumptions that can be made regarding the equilibration of the labour market and the consequent effects of changes in aggregate demand on wages and prices.

The assumptions made in SALIO model is that of a perfectly elastic supply of labour where wages are fixed and only changes in employment give rise to increase in income. It this corresponds to the short-run fixed price Keynesian aggregate demand model. It is also not very clear or explicit as to what part of household income does the SAL model incorporate in closing the model. We know that the household sector is integrated into the model, but we have no explicit way of telling which incomes are included or how taxes are netted out, etc. In the mathematics of the system above we tendered a full system in a detailed way of how this closure can be made. This is not clear from the presentation of K&R in their SALIO and our fear is that a serious misspecification of the multipliers may have resulted.

The effect of changes in aggregate demand on the consumption of each commodity is assumed to be proportionate to the change in aggregate demand, reflecting an assumed unchanged composition of expenditures. This assumption is equivalent to assuming that the income elasticity of demand for all products is the same (income elasticity is the percentage change in quantity demanded of a commodity divided by the percentage change in income). This assumption is difficult particularly when a long time horizon is employed. This is because the demand for some types of goods will be relatively inelastic to changes in incomes (such as the demand for necessities such as food and agricultural outputs), while the demand for other goods is relatively elastic (such as the demand for durable goods and services). As a result, this assumption of an unchanged product composition of aggregate demand will cause the change in demand for food and agricultural products in the SALIO model to be overstated and cause the changes in demand for durables and services to be understated. The longer the period of the predictions the larger are the errors.

The Employment Model

In the SALIO model, it is assumed that labour requirements in each industry are proportionate to output, and that labour employed is equal to labour demand. Wages are assumed to be determined exogenously to the model, reflecting an implicit assumption that there is excess supply of labour which has no feedback effect on wages. Under these circumstances, the calculation of the employment effects of production changes predicted by the IO model is trivial and straightforward.

It must be emphasized that the grounds for assuming the demand for labour to be wage inelastic and proportional to output are very weak, and consequently it is necessary to take the employment predictions of the SALIO model made with linear and constant employment-output coefficients over long periods of two generations with a considerable grain of salt. In effect what is has been assumed here is either that wages do not change over time (productivity change is zero) relative to other costs or that there is no substitutability in production between labour and other inputs. Both assumptions are clearly false in the long run if not in the medium term. The weight of empirical evidence indicates that the long-run elasticity of substitution is closer to unity than zero (the Leontief production function employed in the SAL model assumes this elasticity to be zero).

Cyclical variations in productivity due to variations in hours worked per employee, employer hoarding of skilled worker and massive restructuring of working environments engendered by globalization and the ICT revolution have caused major changes in the relationship between employment and output. For these reasons, the employment predictions of the SAL linear static input output model should regarded as indicative of a medium term forecast for between 2-5 years relevance only.

The Interface Model

The modeling approach uses resource production outputs from a landscape simulator model (*ALCES*) based on Stella to shock the economy over a 50-year simulation period. Consequently an interface was developed to convert the outputs to a form that the IO model can use. This was described in an accompanying report which describes the SAL IO model and the interface (Appendix II).

The Stella model generates simulations in physical units while the IO model uses values. The conversion of physical units into value units is then necessary to connect the two models together. Since there are no one-to-one connections between the two models an interface facility had to be developed. Outputs are converted to values and these are multiplied by the technology columns of the Use Matrix to change them into purchases. These purchases are changed into final demand entries to which the multiplier matrices were used to calculate their impacts.

Input purchases are in purchaser prices but IO entries are in producer prices. Therefore one needs to net out the many margins that are embedded in these purchases. This necessary conversion is done correctly. We are not as confident about the price adjustments on each item purchased. The discussion is not clear or helpful. Provincial costs are used but these proved to be less than the estimated values and had to be prorated down. Even when all of this is accepted, there is no mention about prices outside the base year of the IO system. The technical coefficients are relevant only for 1999. Values outside this period must be rolled back to this period to calculate all of the technical relationship in the system. Failure to do so is another source of error particularly for employment impacts.

Calibration and Estimation Issues

The implementation of the SALIO model required the processing of large data sets that involved the compilation, revision, regionalization, disaggregation, calibration and estimation of many variables and relationships. A large number of procedures were employed and many compromises were made out of necessity. In what follows we will discuss each of these issues separately under the task that were carried out by the developers of the SAL model.

The Input Output Tables

Statistics Canada generates three components of the IO system (Use, Make and Final Demand Tables) for each province at regular intervals. The most recent tables are the Inter-provincial Tables for 1999. The Alberta tables were extracted from these tables. Unfortunately, these tables are not supplied in a complete form. The only available ones are in the S-Aggregation form which is quite small with manufacturing and agriculture is each only one industry. Agriculture has also only two commodities. Besides Statistics Canada offer these tables with many hidden entries that are left for the user to guess their values under the pretext that their disclosure would contravene confidentiality rules binding Statistics Canada. SALIO developers were obliged to deal with these missing entries. In our opinion they opted to guess their values in a very simplistic way either through trying to estimate their value using column and raw totals which are not often available given that Statistics Canada has even blanked these totals or by aggregating these missing entries into a dummy residual column or raw. This is not the best way to deal with these missing variables. We faced the same problem ourselves in building the DEIM Model for Alberta. Instead we used earlier versions where these entries were available and employed RAS methods on the missing entries whose control raw and column totals were available or could be obtained from alternative Statistics Canada publications. Comparing our multiplier values to the output multipliers displayed in Table 6.1, we found out that they tend to differ from our estimated multipliers. This difference could be the result of different structural equations missing from SALIO model, but they could also be the result of some missing data. We suspect a combination of both of these factors.

Aggregation Issues

The Southern Alberta Landscapes: Meeting the Challenges Ahead has used Statistics Canada Input-Output (IO) model for Alberta in 1999 as its starting grounds. The model is recalibrated to fill in some of the missing entries and then disaggregated to allow for a larger set of primary sectors as the Small Aggregation of Statistics Canada Inter-provincial Input Output Tables allow for only one agricultural industry and two agricultural commodities (Grain and other Agricultural Products). The need for further disaggregation was primarily necessitated by the fact that output of ALCES is more disaggregated in the production of primary commodities than the IO model. In order to bring about similarity in scope for the two models, the IO model was further disaggregated. This disaggregation was needed in three areas. Agriculture was disaggregated into three sectors—Dryland Production, Irrigated Production and Confined Feeding Operations. Census data for areas under various agricultural crops by municipal regions and the total value of provincial crop production were available from Alberta. The allocation of provincial totals to different areas by crop was not available.

It had to be estimated. The estimation procedures, however, are unfortunately arbitrary and this has lent another element of uncertainty to the model.

Let is quote one of their statements about apportioning costs by region and crop…"Total provincial expenses, as reported by Statistics Canada census data, were **arbitrarily** proportioned into crop and livestock expenses." (K&R p. 22) Kulshreshtha and Russell should be commanded on their honesty but surely there are different ways of apportioning these costs that may not be as arbitrary as their method. It certainly raises some question about their procedure.

The disaggregation of the manufacturing sector into four sub-sectors is also problematic. One wonders why K&R could not use the standard and commonly used RAS methods in this instance. They obtained coefficients on many industries from the Alberta Bureau of Statistics but there is no mention that these were adjusted to preserve the consistency of the Use and Make matrices. We disaggregated the manufacturing sector of Alberta into 16 industries using the total manufacturing commodity uses (almost fully specified in S-aggregation) and the value added by manufacturing sector from other Statistics Canada data on GDP by industry in Alberta. It would have been nice to see that K&R had used the same procedure. We would have a better basis to test the differences between our two systems.

The mining sector was justifiably reconfigured such that Crude Petroleum and natural gas production stand out. The coefficients of these sectors were obtained from Alberta Bureau of Statistics. But again no mention of any adjustments made to ensure that these coefficients preserve the consistency of the User and Make matrices.

The Estimation of the Propensity to Spend

In order to derive the induced effects of the different scenarios, the household sector must be endogenized (incomes of households and their consumption are solved within the model). This requires both the consumption pattern of these households which is typically given by the final demand of the system and their income. The latter is a difficult question which requires translation of value added coefficients into disposable income. This involves using wages and salaries, dividends, income of unincorporated enterprises and the addition of transfer payments which are typically not included in the IO system. Furthermore the personal income taxes must be eliminated. As mentioned in the mathematical section of this review, the authors have not shown clearly this specification. What they have shown is the conversion of income into consumption using the Marginal Propensity to Consume (MPC). This is appropriate in a short-term application of the model, but not of the type used here. A long-run consumption function (using permanent income specification or the life-cycle format) would require the use of the Average Propensity to Consume (APC). The long run consumption function is one in which the MPC is equal to the APC. Surely the 0.99 MPC showing up in their estimation is the result of missing variables (wealth, liquidity, etc.) and what is generally referred to in econometrics—specification errors.

The adjustment they make to reduce it from 0.99 to 0.875 is arbitrary, but is not consistent with the long-run estimates of consumption functions in Alberta of the type which show a long run MPC=APC of 0.81. It is the latter that we have used in our model.

Employment Data

The employment output data used by K&R (Table 3.7 P.33) are typically higher than the corresponding values we have estimated. This we suspect to be the result of dividing more recent employment data by the 1999 based IO. We are also puzzled by the employment coefficients associated with the dummy sectors (such as transportation margins and operating office). These should not be treated as production activities.

Alternative Methodologies

It is logical to ask whether another methodology exists that it can be used to avoid the deficiencies in the approach used by SALIO. In other words, is there an alternative to the Input Output model used by K&R?

There are two competing systems to the IO approach—econometric models and general equilibrium models. Econometric models require long time series of data on all variables. Relationships are estimated on the basis of stochastic properties of variables. Unfortunately not all variables of interest are stochastic or for which there exist long time series. This makes the full and comprehensive applicability of econometric models too expensive and infeasible. On the other hand, the econometric modeling approach liberates the user from all the deterministic fixed coefficients approach of IO model.

Alternatively, the Computable General Equilibrium (CGE) model is a compromise between the IO approach and the econometric approach. It avoids some of the major pitfalls of the IO approach by using production functions that allow for substitution among inputs and thus avoids the fixed technology assumption inherent to the IO approach. It also uses consumption specifications that allow choice among commodities and sensitivity to their different relative prices. These are recognized advantages. However, the approach which introduces these advantageous behavioural responses is based on a calibration method that is typically arbitrary. It fits relationships to a given intercept but uses elasticities that are not typically estimated econometrically from actual local data. Therefore, one can generate any number of responses and impacts depending on the "arbitrarily chosen" elasticity. Furthermore, the structure of the economy that is captured in the input output framework is not typically featured in these models. Structural data are not available on a time series basis and thus become difficult to estimate using econometric relationships and tools. They are accounting constructs and relationships and not stochastic variables and relationships. Some CGE models incorporate the structural information into their frameworks, but then we are in the hybrid class of models. It is these hybrids that I would like to recommend. They integrate input output information and relationships without restricting them to fixed and linear parameters. I would also like to point out that there are already in use many models that bring together CGE elements and econometrically estimated relationships to the same applications for which SALO was designed. In the recommendations section below I will pint out where these compromises can be made.

Recommendations

Alberta environment has invested wisely in developing the two sister models-SAL and ALCES. Together they form a powerful tool for exploring future outcomes of different policy options.

There are, however, a few improvements that can be made to enhance the structure, reliability and relevance of the model in generating more acceptable and accurate simulation results over time. Some of these improvements are listed below:

First, the specification of both the open and closed models should include imports and taxes in the structure of the equations and therefore in the matrix inverses and to introduce some dynamic elements into the model formation that would make it more amenable to long-term forecasts. These additions may take the form of adjustment lags between supply and demand, and/or capital-output matrices where ICORs can be employed along the diagonal.

Second, the employment output functions should either be estimated as nonlinear functions of value added or an error correction mechanism along the lines used in the Canadian CANDIDE model can be introduced to adjust the income and employment impact results by the errors between predicted and actual values over a known period. These errors compensate for both the fixed technology assumption as well as the fixed Cobb-Douglass utility function underlying the fixed commodity patterns in final demand. If this is not the preferred adjustment, it is possible to estimate specific demand functions by commodity using Linear Expenditure Functions.

Third, the regionalization approach is rather crude. It may be necessary to re-estimate the allocation weights along some known magnitudes of capacity or trade rather than the use of the LQ to suggest that the IO coefficients are identical to the provincial if LQ>1 or the share of the LQ if it is less than one. The IO coefficients are both technical and market share coefficients coming from both the D and B matrices. The adjustment by location coefficients suggest that the elements of the B matrix are identical for both regions in Alberta and the only adjustment is in the market shares and only if they are not equal to the provincial of the commodity.

Fourth, the dis-aggregation of the transaction matrices can be anchored on more solid grounds using RAS methods than simply lumping the unknowns into one residual sector.

Fifth, we would like to suggest that the authors conduct a thorough review of the allocation procedures of the various activities in the disaggregation process. Some of these allocation procedures are rather arbitrary and can be anchored on more solid grounds. This is particularly the case with regards to the disaggregation of agricultural products, the assignment of provincial production costs to regions per cost item, the use of inventory level as a proxy for the determination of production level in Livestock and Confined Live stock estimation, etc.

Sixth, a rewrite of the Report is perhaps necessary. There are a few typos and some awkward statements that can easily be corrected.

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